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STATOR FOR A HYDRODYNAMIC TORQUE CONVERTER

SPECIFICATION

Technical Area

[0001] The invention pertains to a stator for a hydrodynamic torque converter according to the introductory clause of Claim 1.

State of the Art

[0002] A stator for a hydrodynamic torque converter is known from DE 195 33 151 A1, which is located between a pump wheel and a turbine wheel and has stator elements in the form of a stator hub with stator vanes mounted thereon. The vanes are connected to each other in the radially outward area by a stator rim. The vanes have the effect of feeding the fluid arriving at the turbine wheel to the pump wheel at the desired angle.

[0003] A stator of this type can be produced in various ways. For cost reasons, an injection-molding process is preferred in which the molds are drawn in the axial direction. The molds have cavities, into which material is introduced during the injection-molding process. After this material has cooled, the molds are pulled apart in the axial direction to release the stator. Aluminum is the material which is usually used for an injection molding process of this type. Because of its low viscosity in the heated state, however, the material can escape through the contact zone between the molds, which results in undesirable fins on the

vanes. To remove these fins, a chisel is pushed in the axial direction between the flow outlet of a first vane and the flow inlet of the second vane. While the fins are being cut away, forces act on the inserted chisel and threaten to fracture it, since the blade of the chisel is very narrow in the circumferential direction. As a result, the blade of a chisel of this type usually has a minimum width of about 4 mm. As a result of this, however, a corresponding offset equivalent to the width of the chisel is created between the flow outlet of the one vane and the flow inlet of the other vane in the circumferential direction. This has the effect of reducing the length of the vane which is available to guide the flow, which leads in turn in lower efficiency and to an inferior characteristic. As a result, the transmission ratio of the converter is reduced.

[0004] Because of these disadvantages, stators are often made of a thermoset plastic. According to this approach, a thermoset powder is introduced into a compression mold and consolidated into a stator under the effects of temperature and pressure. Although the stator has a smooth surface, the necessary admixture of glass fibers or carbon fibers means that it cannot be cut by machine, because this would cause cracks to form. The contact between these cracked surfaces and another material such as steel has the effect of roughening the surface of this other material, and this results in considerable wear.

[0005] These types of thermoset plastic stators are preferably drawn in the radial direction. Although it is possible in this way to obtain vanes with the optimal shape, the production method is very expensive, because, after the thermoset powder has been “baked”, the molds, the number of which is equivalent to the number of vanes, must be pulled away in the radially outward direction.

Task of the Invention

[0006] The invention is based on the task of designing a stator in such a way that it can be produced at low cost and will not fracture, whereas it can also offer good efficiency and a good characteristic at the same time.

Description of the Invention

[0007] This task is accomplished according to the invention by the features given in the characterizing clause of Claim 1.

[0008] Through the use of a blank for the various groups of stator elements, i.e., the stator hub segments, the stator vanes, and the stator rim segments, the particular advantage is obtained that a considerable amount of design freedom is obtained for each group of stator elements. Thus each group of stator elements can be shaped in the best possible way to achieve optimal operating results. Of essential importance here is the design of the vane group of stator elements, because these affect the efficiency and the characteristic of the hydrodynamic torque converter. By properly laying out the geometry of the areas on the blank which will later form the vanes, it is easy to create the basis for a system of stator vanes in which the individual vanes overlap each other to the maximum possible extent, which promotes efficiency. In the case of the group of hub segment elements and the group of rim segment elements, however, the dimensionally stable support which they give to the vanes and their ability to keep the vanes properly oriented in the desired planes is probably the more important aspect, which means that the hub segments and the rim segments must offer sufficient strength after all the elements have been connected together to form a unit.

[0009] The individual groups of stator elements can be freed from each other in the blank by a separation process. The phrase “freed from each other” has been chosen to emphasize that the intention is not to separate the individual stator element groups completely from each other but rather to separate them only just enough so that these groups, which remain connected to each other at predetermined points, can be moved by a deformation process such as plastic metal working out of the original plane of the blank into new planes of extension deviating from the original plane, so that ultimately the desired 3-dimensional stator can be formed out of the original 2-dimensional blank. The deformation processes are not limited to changes in the relative positions of the stator element groups with respect to each other but can also include the plastic deformation of the individual components of each group of stator elements. This type of plastic deformation appears to be especially important for the formation of the vanes in particular, because a considerable effect can be exerted on the operating behavior and efficiency of the hydrodynamic torque converter by manipulating the profile of the vanes. It is also true that the other groups of stator elements can be subjected advantageously to plastic deformation in order to orient them, for example, along lines of curvature, so that both the hub segments and the rim segments extend around the center axis of the stator. It is easy to see here that the lines of curvature of the hub segments will differ from those of the rim segments because the distances which separate the two groups from the previously mentioned center axis are different.

[0010] By attaching the individual segments of the stator hub to each other, which can be done, for example, by welding, brazing, or bonding them together with an adhesive at their abutting ends, a segmented stator hub is obtained which can be set onto a base body hub, which acts as a carrier. The two components together, i.e., the segmented hub and the base

body hub, are thus ultimately able to form the complete stator hub.

[0011] It is possible to dimension the original blank in such a way that, after the individual hub segments have been lined up in the circumferential direction and connected to each other, a single segmented stator hub is obtained, which can be drawn onto the base body hub and then completed simply by connecting the two abutting ends, which are now facing each other. But it is also equally possible to provide shorter blanks and to produce two or more segmented hub sections. These shorter sections are then connected to each other after they have been fastened to the base body hub. A segmented hub formed in this way must, of course, will be fastened to the base body hub in such a way that no relative movement is possible between the segmented hub and the base body hub in either the axial direction or the circumferential direction. To reduce the number of connecting points, it can be preferable to provide a retaining device between the segmented hub and the base body hub. This retaining device acts in the circumferential direction and/or in the axial direction and fastens the segmented hub to the base body hub so that the two parts cannot move relative each other. To form the retaining device, a profiled channel, for example, can be machined into the base body hub. The segmented hub is given a mating shape, which can fit into the channel. The positive connection between the base body hub and the segmented hub prevents any movement between these two components in the circumferential and/or axial direction. A permanent connection can also be provided for safety reasons between the the base body hub and the segmented hub in the form of individual spot welds, although the two components can also be brazed together or bonded together with an adhesive, which can also be done in a spotwise manner.

[0012] In contrast to the hub segments, which must be attached to each other at their abutting ends, the rim segments can be joined together without any additional connecting

measures in that, on the blank, a shroud is provided, at which the blank is not interrupted by separation processes, in contrast to the other groups of stator elements. During the deformation processes which are to be performed, therefore, the stator rim segments can, together with the shroud, obtain the curvature which is required for the rim to surround the center axis.

[0013] Ideally, the blanks consist of a metallic material which ensures that the finished stator has the necessary stability and which at the same time offers good ductility so that the necessary deformation process, preferably a cold working process such as deep-drawing or die forming, can be successfully performed. As a result, by the use of appropriately shaped tool carriers, it is possible not only to orient the individual groups of elements properly with respect to each other without material problems but also to carry out the plastic deformations which are also required for the individual stator element groups such as adjusting the curvature of the vanes.

[0014] Additional special design features of the individual groups of stator elements are described in the claims. By interaction with each other, these features improve the stability of the stator and increase its efficiency even more.

[0015] The invention is illustrated in the attached drawing and is explained in greater detail below:

[0016] Figure 1 shows a partial cross section through a torque converter, including essentially the stator with its various groups of elements;

[0017] Figure 2 shows a blank used for the production of the stator after the various groups of elements have been freed from each other;

[0018] Figure 3 shows part of the blank according to Figure 2;

[0019] Figure 4 shows a perspective view of the stator after the blank of Figure 2 has been subjected to various deformation processes;

[0020] Figure 5 shows a top view of the stator from an axial perspective;

[0021] Figure 6 shows a part of the stator from a radially outer perspective;

[0022] Figure 7 shows a base body hub serving as a carrier for the stator;

[0023] Figure 8a shows a special design of the radially outside surface of the base body hub;

[0024] Figure 8b shows a cross-sectional view along line VIIIb-VIIIb of Figure 8a;

[0025] Figure 9 shows a metal-forming tool used for the production of the stator; and

[0026] Figure 10 shows a cross-sectional view along line IX-IX of Figure 9.

[0027] Figure 1 shows only the inventive area of a hydrodynamic torque converter. No attempt has been made to illustrate or to describe the torque converter as a whole, because these torque converters are known from the state of the art, e.g., from DE 41 21 586 A1.

[0028] The pump shell 1 shown in Figure 1 is used to form a pump wheel 2, which cooperates with a turbine wheel 3. The turbine wheel is permanently connected in its radially inner area to a turbine hub 4, which is connected by a set of teeth 5 to a drive shaft (not shown).

[0029] The previously mentioned pump shell 1 is attached in its radially inner area to a pump hub 6, which extends toward the power takeoff. Axially between the pump wheel 2 and the turbine wheel 3 there is a stator 7, which is mounted by way of a first axial bearing 8 between the turbine hub 4 and a freewheel 9 and by way of a second axial bearing 10 between the freewheel 9 and the pump hub 6. The two axial bearings 8 and 10 are each provided with grooves 11, 12 for the hydraulic fluid with which the converter circuit is supplied, especially

via the grooves 11 in the axial bearing 8.

[0030] The axial bearing 8 is formed as a single piece with a stator hub 15, illustrated only schematically, on the circumferential area of which vanes 17 are provided. The radially outer ends of these vanes are connected to each other by a rim 19. The freewheel 9, on which the stator 7 is mounted, has an outer freewheel ring 23, which is guided by clamping bodies 25 on an inner freewheel ring 27, which is connected nonrotatably by a set of teeth 29 to a power takeoff element (not shown). Fluid for supplying the converter circuit via the groove 11 can be guided radially between this power takeoff element and the power takeoff shaft connected nonrotatably to the turbine hub 4.

[0031] As shown in Figure 2, a blank 32 is used to produce the stator 7 shown in Figure 1. The original plane 40 of this blank is exclusively 2-dimensional.

[0032] The blank 32 has stator hub segments 36 on the side designated by the letter U in Figure 2; these segments have abutting ends 54, 56 adjacent to each other, where in each case the abutting end 56 of the hub segment 36 closer to the side L of the blank 32 is in contact with the abutting end 54 of the hub segment 36 closer to the side R of the blank 32.

[0033] Each hub segment 36 of the stator has a first bending line 74, which forms the boundary between it and a vane 17, which for its own part has a second bending line 76, which forms the boundary between it and a stator rim segment 38, where all of the rim segments 38 of the blank 32 are formed as integral parts of a common shroud 39, which extends along the side of the blank 32 marked with the symbol O in Figure 2. The hub segments 36 form a first group 34 of stator elements; the vanes 17 form a second group of stator elements 34; and the rim segments 38 together with the shroud 39 forms the third group 34 of stator elements. A segment 33 of the blank containing elements of all three stator groups 34 is shown in enlarged

detail in Figure 3.

[0034] After the blank 32 has been laid in a workpiece carrier designed in the usual way (and therefore not shown) with a flat receiving area for the blank 32, the blank is subjected to separating operations by means of a stamping tool, also of the conventional type, by means of which the individual segments 33 of the blank are freed from each other and unneeded or even interfering areas of the blank are completely removed. The areas which are removed from the blank include both the cutouts 53 in the area of the hub segments 36 on side U of the blank 32 and also the compensating cutouts 70 between the hub segments 36 and the adjacent vanes 17. For the sake of clarity, the lines along which one of the blank segments 33 is cut during the process of separating it from the two adjacent blank segments 33 are emphasized in Figure 2 by the shading of the edges.

[0035] The blank 32 is now transferred to a different workpiece carrier 90, the basic design of which can be derived from Figures 9 and 10. The workpiece carrier 90 consists of a first metal-forming tool 86 and a second metal-forming tool 88, which cooperates with the first. The second metal-forming tool 88, which, in the area of the vane 17, is at the bottom in Figures 9 and 10, has a receiving bed 92 for the vane 17. This receiving bed 92 has the shape of what will later be the curvature of the vane. In cooperation with this receiving bed 92, a ram 94 is formed on the first metal-forming tool 86, which is at the top in Figures 9 and 10. When this ram is lowered toward the receiving bed 92 of the second metal-forming tool 88, the vanes 17 are plastically deformed, where the curvature of the vanes 17 in this direction obviously depends on the shape of both the receiving bed 92 and the contact side of the ram 94. Of course, both the receiving bed 92 and the ram 94 can also be provided with a curvature in the direction in which the vanes 17 extend as shown in Figure 10, so that ultimately the

vanes 17 are curved both in the radial direction and in the axial direction. A great deal of freedom is available with respect to the design of the vanes 17, which means that the geometry of the vanes 17 will depend essentially on the fluid dynamics requirements.

[0036] Figure 10, which shows a cross-sectional view of Figure 9 along line X-X, shows that the vanes 17 are located preferably in a new plane of extension 47, which, although it may agree essentially with the original plane 40 of the blank, can nevertheless deviate from it as a result of the possible plastic curvature of the vanes 17. In contrast, the stator hub segments 36 are bent around the first bending line 74 into a new plane of extension 42, and the stator rim segments 38 are also located now, after deformation around the second bending line 76, in a new plane of extension 46. The new planes of extension 42 and 46, i.e., the plane of the stator hub segments 36 and the plane of the stator rim segments 38, can preferably be essentially perpendicular to the original plane 40 of the blank. As the bending arrows B1 and B2 in Figure 10 show, however, the stator hub segments 36 are bent around the first bending line 74 in the direction opposite that in which the stator rim segments 38 are bent around the second bending line 76.

[0037] The results of these deformation operations is illustrated in Figures 4-6 of the drawing. Figure 4 shows a perspective diagram of part of a stator. Figure 5 shows a top view looking in the axial direction, and Figure 6 shows a view from a radially outer perspective in the viewing direction VI of Figure 5. Before the details are discussed, it should be mentioned that, in Figures 4-6, arrows are used to indicate the flow direction of the fluid in the area of the vanes 17. Figure 5 shows the axial side of the flow inlet.

[0038] During the course of the previously mentioned deformation operations, the hub segments 36 as well as the rim segments 38 opposite the vanes 17 are bent in such a way

around the bending lines 74, 76 shown in Figures 2 and 3 that the hub segments 36, as can be seen especially clearly in Figure 5, proceed around a line of curvature 50 at a distance R1 from the center axis 48 of the stator 7. The hub segments 36 thus assume their positions in the new plane of extension 42 (Figure 4). The rim segments 38, however, proceed together with the shroud 39 around a line of curvature line 52, which is a certain distance R2 away from the center axis 48 of the stator 7, the stator rim segments 38 now assuming positions in their new planes of extension 46 (Figure 4). As previously described, the vanes 17 remain in a plane of extension 44, which can be essentially the same as the original plane 40 of the blank, although the now-present curvature of the vanes 17 causes an at least partial departure from the original plane of the blank. The curvature of the vanes 17 can be seen especially clearly in Figures 4 and 6.

[0039] Because of the new orientation produced during the course of the deformation operations, the hub segments 36 arrive in positions relative to each other in which, as Figures 4 and 6 show especially clearly, circumferential trailing lips 66 (see Figures 2 and 3) offer a receiving area 68 (Figure 6) for the adjacent vane 17 and also ensure that the segmented stator hub 58, formed by the lining-up of the hub segments 36 in a circumferential row, forms a closed edge 108 all the way around the circumference on the flow outlet side A, as shown in Figures 4 and 6. At the same time, an engaging projection 72 of the hub segments 36 on the flow inlet side E (see Figures 2 and 3) projects in each case into the compensating opening 70 in the adjacent hub segment 36, so that an uninterrupted, closed edge 110 is also obtained on the flow inlet side E of the segmented hub. To this extent, the opening 53 shown in Figure 2, formed in each of the hub segments 36 by a separating operation, assists with the formation a continuous segmented stator hub 58 on both closed edges 108, 110 and with the formation of a

receiving area 68, which supports the vanes 17 against the action of the flow. Merely for the sake of completeness, it should be remarked that the straight shape of the receiving area 68 shown in Figures 2 and 3 is based on the assumption that the vane 17 is also essentially free of curvature, at least in the section extending along the receiving area 68. In a practical design, such as that shown in Figures 4 and 6, however, the vanes 17 can be formed with a curvature, to which the shape of the receiving area 68 will, of course, conform.

[0040] To return to Figures 2 and 3, these show an overlap area 80 between the vanes 17 and the rim segments 38. It is along this area that, during the course of the separating operations, the vanes 17 are freed from the rim segments 38. After the rim segments 38 have been bent into the plane of extension 46 as a result of the deformation processes, a radially outer support 79 element which braces the vanes 17 against the action of the flow is created in the area of the outside diameter of the stator 7 along the second bending line 76, whereas the shroud 39, which connects the individual rim segments 38 to each other in the circumferential direction, introduces a significant stability-increasing effect. As Figures 4 and 6 show in particular, the rim segments 38 in their new plane of extension 46 also ensure that the vanes 17 are kept at the necessary relative distance from each other in the circumferential direction, in that the support elements 79 of the rim segments 38, which proceed from the separation line 78, work together with the associated receiving areas 68 of the hub segments 36 to position the vanes 17 at their two radial ends and thus establish the desired circumferential gap between a flow outlet edge 84 of the vane 17 which leads in the circumferential direction and the flow inlet edge 82 of the vane 17 which follows in the circumferential direction. As the flow arrows entered in Figures 4 and 6 indicate, this gap serves, on the side designated by the letter E in these figures, as a flow inlet 81 between two adjacent flow inlet edges 82, and on the side

designated A of the figure, as a flow outlet 83 between two adjacent flow outlet edges 84. In addition, as shown in the half of Figure 4 which contains the stator rim 19, the circumferential row of rim segments 38 together with the shroud 39 form a radially outer boundary, whereas the segmented stator hub 58 forms a radially inner boundary of the flow inlets 81 and flow outlets 83 located radially between these two boundaries.

[0041] Formed in this way, the hub segments 36 can be connected to each other by welding or possibly by brazing or adhesive bonding at the contact points located between the engaging projections 72 and the compensating openings 70 and at the circumferential ends of the adjacent circumferential trailing lips 66, so that the previously mentioned segmented stator hub 58 is obtained. Because the rim segments 38 are connected to each other in any case by the shroud 39 and cooperate with the segmented stator hub 58 to hold the vanes 17 in their predetermined, defined positions, the vane area 96 of the stator 7 is thus also obtained in finished form. If the original blank 32 was dimensioned in such a way that the vane area 96 completely encloses the outer circumference 100 of a base body hub 60, shown schematically in Figure 7, the segmented stator hub 58 will be attached by welds 98 or possibly brazed or adhesively bonded to the outside circumference 100 of the base body hub 60, whereas two ends 112, 114 of the vane area 96 will be connected to each other preferably also by welds 99 (compare Figure 5), alternatively by brazing or by the use of an adhesive, in that the abutting ends 62, 64 of the stator rim 19 provided for this purpose and shown in Figure 2 and the abutting ends 65, 67 of the segmented hub 54 on the two circumferential ends 112, 114 of the stator rim 19 and segmented stator hub 58 are connected to each other. The partial view shown in Figure 5 shows the points at which the ends 112 and 114 are connected to each other in detail.

[0042] Even better conditions with respect to fabrication are obtained when the vane area 96 extends not over an angle of 360° but rather over only a portion thereof, such as for example over an angle of 120° . The individual vane areas 96 are thus easier to fabricate and can then be connected to each other when the segmented hub is attached to the base body hub 60, for which purpose, in the previously described manner, both the abutting ends 65, 67 of the individual sections of the segmented stator hub 58 and also the abutting ends 62, 64 of the individual sections of the stator rim 19 are connected to each other by welds 99 (or by brazing or adhesive bonding) and also by welds 98 (or by brazing or adhesive bonding) to the base body hub 60.

[0043] Figure 8a shows a view of the base body hub 60 radially from the outside, without the mounted vane area 96. In contrast to the design according to Figure 7, the radially outer circumference 100 of the base body hub 60 is designed with a retaining device 61 in the form of a profiled channel 102, into which the segmented stator hub 58 (see Figure 8b) is inserted, where the latter, as the view radially from the outside reveals, is adapted with respect to the course of its two closed hub edges 108, 110 to the geometry of the axial edges 104 of the profiled channel 102. As a result of this design of both the outer circumference 100 of the base body hub 60 and of the segmented stator hub 58, a positive connection 61 is obtained, which prevents relative movement between the segmented stator hub 58 and the base body hub 60 in both the axial direction and the circumferential direction. In this design, there is no need for the welds 98 (or brazing or adhesive bonding) shown in Figure 7 between the segmented stator hub 58 and the base body hub 60. Thus, to produce the stator 7, it is necessary only to connect the individual vane areas 96 circumferentially to each other in the manner previously described.

[0044]	1	pump shell
	2	pump wheel
	3	turbine wheel
	4	turbine hub
	5	set of teeth
	6	pump hub
	7	stator
	8	first axial bearing
	9	freewheel
	10	second axial bearing
	11, 12	groove
	15	stator hub
	17	stator vanes
	19	stator rim
	23	outer ring of the freewheel
	25	clamping body
	27	inner ring of the freewheel
	29	set of teeth
	30	stator elements
	32	blank
	33	segments of the blank
	34	groups of stator elements
	36	stator hub segments

38	stator rim segments
39	shroud
40	original plane of the blank
42, 44, 46	new plane of extension
48	center axis
50, 52	lines of curvature
53	openings
54, 56	abutting ends of the stator hub segments
58	segmented stator hub
60	base body hub
61	retaining device
62, 64	abutting ends of the stator rim
65, 67	abutting ends of the segmented stator hub
66	circumferential trailing lip
68	receiving area
70	compensating opening
72	engaging projection
74	first bending line
76	second bending line
78	separation line
79	support
80	overlap area
81	flow inlet

82	flow inlet edge
83	flow outlet
84	flow outlet edge
86, 88	metal-forming tools
90	workpiece carrier
92	receiving bed
94	ram
96	vane area
98, 99	spot welds
100	outside circumference
102	profiled groove
104	axial edges
106	converter circuit
108, 110	closed edges of the segmented hub
112, 114	circumferential ends